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CONCEPT OF OHMIC HEATING ON FOODS - A REVIEW

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ABSTRACT

Ohmic heating is a developing innovation, with vast number of real and future applications. The possibilities for ohmic heating include blanching, evaporation, dehydration, fermentation, extraction, sterilization, pasteurization and heating of foods, to serving temperature. The knowledge of electrical conductivity of food materials and mathematical models are considered important, for the designing of the ohmic heating system. This review paper describes the concept, experimental setup and applications of ohmic heating.

KEYWORDS: Foods, Ohm's Law, Resistance Heating, Electrical Conductivity & Voltage Gradient

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Review Article

INTRODUCTION

Conventional heating processes essentially consist of, heat-transfer mechanisms of conduction, convection and radiation. The internal resistance by conduction results in very heterogonous treatment and notable loss of product quality. To overcome these problems, alternative technologies utilizing electrical energy directly in food processing, have attracted interests in the food industry in recent decades. Development of new technologies for thermal food treatment is still of great industrial and scientific interest. Ohmic heating is one of these new technologies. Ohmic heating technology has become attractive in the past few years, due to the availability of energy at reasonable cost and improved designs.

Ohmic heating is also termed as 'electro heating' or 'resistance heating', in which food is heated by passing an alternating electric current, because of the electrical resistance of the food. Heat is generated instantly and volumetrically inside the food materials, due to the ionic motion. The amount of heat generated is directly related to the current induced by the voltage gradient in the field, and the electrical conductivity of the materials being heated (Icier &Ilicali, 2005).

The mechanism of ohmic heating is taken from Ohm's Law on the basis of the voltage, resistance and the current. It is considered as one of the modern technologies, where the food is converted into an electric resistance. The alternative current passes through the food, and the electrical energy is transformed into heat energy. The heat is distributed inside the food uniformly and rapidly. The heat direction shall be from inside to outside, on the contrary of using hot surfaces in the traditional methods in which heating direction is form outside to inside and slower.

HISTORY

The idea of ohmic heating of foods is not new. In the nineteenth century, a few procedures were patented

that utilized, electrical current for heating flowable materials. In the mid twentieth century, "electric" pasteurization of milk was accomplished by passing milk between parallel plates with a voltage differences between them. The innovation for all intents and purposes, vanished in succeeding years obviously because of the absence of appropriate inert electrode materials and controls. Since that time, the innovation has gotten constrained enthusiasm, with the exception of electro conductive thawing (Ruan*et al*, 2001).

Modern developments in the designs for ohmic heating have turned out to be accessible in the past two decades. The specific enthusiasm for this innovation comes from continuous food industry enthusiasm, for aseptic processing of liquid particulate foods. Traditional aseptic processing for particulates depend on heating of the liquid phase, which at that point exchanges heat to the solid phase. Ohmic heating evidently offers an appealing option, since it heats food materials through internal heat generation (Ruan*et al*, 2001).

PRINCIPLES OF OHMIC HEATING

The basic principle of ohmic heating is illustrated in Figure 1. The water and ionic salts present in the foods act as an electricity conducting mediums and also they have a resistance which generates heat, when an electric current is passed through foods. The both ends of product body, was connected with electrodes, which were supplied to AC voltage. The rate of heating is directly proportional to the square of the electrical conductivity and the electric field strength (E), (Ruan*et al*,2001).

Adjustment of electrode gap or the applied voltage varies with the electric field strength. In any case, the most critical factor is the electrical conductivity of the foods and its temperature reliance. On the off chance, that the food has more than one phase, for example, on account of a blend of liquids and particulates, the electrical conductivity of the considerable number of phases must be considered. The electrical conductivity increased with rising temperature, proposing that ohmic heating turns out to be more effective, as temperature increases, which could hypothetically bring about runaway heating. A distinction in the electrical resistance and its temperature reliance between the two phases can make the heating attributes of the system exceptionally convoluted. Since electrical conductivity, was affected by ionic substance, it is conceivable to alter the electrical conductivity of the product (the two phases), with particle (e.g. salts) levels to accomplish effective ohmic heating (Ruan*et al*, 2001).

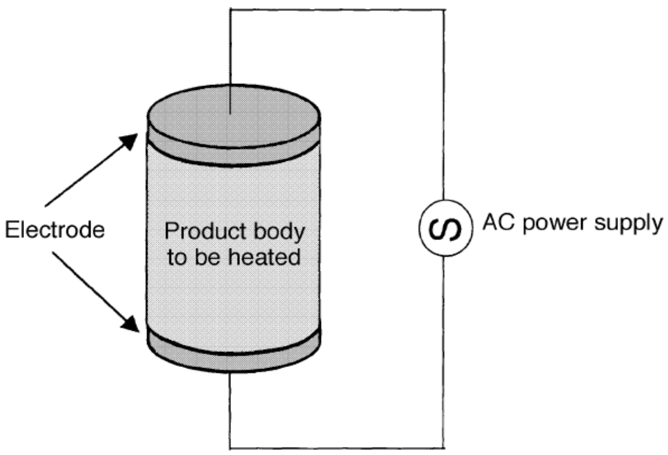

Figure 1: Schematic Diagram Showing the Principle of Holmic Heating

ELECTRICAL CONDUCTIVITY

Electrical conductivity of the materials is the major significant parameter, in ohmic heating. Electrical conductivity is a function of food components. Ionic components (salts), acid and moisture, increases the electrical conductivity, while fats, lipids and alcohols decrease it. Electrical conductivities of samples, can be calculated from voltage and current data, using the following equation (Wang &Sastry, 1993),

$$\sigma = \left(\frac{I}{U}\right)\left(\frac{L}{S}\right)$$

Where;

σ is specific electrical conductivity (S/m),

I is the current through the sample (A),

U is the voltage (V),

S is the area of cross section of the sample (m^2) and

L is the gap between the electrodes (m).

EXPERIMENTAL SETUP OF OHMIC HEATING SYSTEM

Requirements of power, current and voltage, distance between electrodes and electrode configuration, are the main design parameters. Electrical conductivity and heating rate of foods, and type of food materials are also considered, while designing ohmic heating setup (Lima, 2007).

Yin-qiu*et al* (2008) designed and fabricated an experimental setup, for studying the ohmic heating behavior of different liquid food materials. The schematic diagram of this setup, is shown in figure 2. This mainly consists of two components, 1) Ohmic heating unit and 2) Data acquisition system. The ohmic heating unit includes a variable transformer power supply that was used to supply single-phase alternating current, flat stainless steel electrodes and a heating trough for heating of foods. The data acquisition system consisted of the following elements: Digital Conductivity Meter and Thermoscope, by which the temperature and electrical conductivity can be read and recorded, with a digitron meter; two digital multimeters to monitor the voltage across and current intensity through food samples. Electrodes in ohmic heating assume a key part, by passing on the current consistently into the heating medium. Different materials, up until this point, have been utilized as electrodes in various ohmic heating related research studies and applications. In this we had utilized the stainless steel electrode, which has been accounted to be, the most electro chemically active electrode material, during ohmic heating at all the pH values (Samaranayake and Sudhir, 2005). Electrodes were associated with the variable transformer control supply. The food samples were placed in the heating trough, and then the thermocouple was inserted and fitted into the center of the sample appropriately.

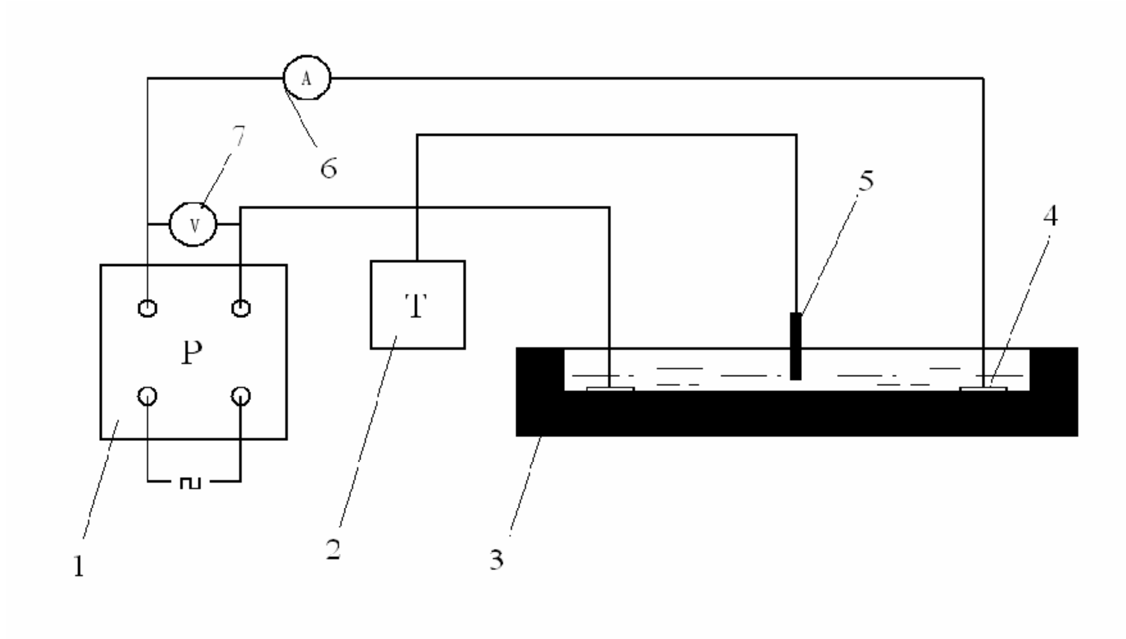

Figure 2:.Schematic Diagram of the Laboratory Scale Ohmic Heating Experimental Setup

- Variable transformer power supply
- Digital conductivity meter and thermoscope
- Ohmic heating trough
- Electrodes
- T type thermocouple
- Digital multimeters.

ADVANTAGES OF OHMIC HEATING (Fellows, 2000)

- Heat exchange coefficients don't constrain the rate of heating
- Temperatures adequate for UHT process can be accomplished
- No danger of surface fouling or burning of food that there is no heat exchange surfaces
- Thermal sensitive foods are not harmed by confined over-heating
- It is suitable for viscous liquids because heating is uniform and does not have the problems associated with poor convection in these materials
- Energy conversion efficiencies are very high (>90%)
- It is suitable for continuous processing.

CONCLUSIONS

Ohmic heating is a developing innovation, with vast number of real and future applications. The possibilities for ohmic heating includes blanching, evaporation, dehydration, fermentation, extraction, sterilization, pasteurization and

heating of foods to serving temperature, including military field, or in long-duration space missions. The knowledge of electrical conductivity of food materials and mathematical models, are considered important for the designing of ohmic heating system. The effects of the applied electric field, the incident electric current and the applied electric frequency, during ohmic heating over different microorganisms and foods (at molecular and cellular level), still need to be more deeply studied. There is also a need for the development of ohmic heating system, for large scale food processing applications and also research is needed, for the development of ohmic heating system for domestic purposes. Therefore, understanding, characterizing and modeling this phenomenon is required, in order to optimize and possibly exploit its effects.

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